#3 priority doc
DHAUGHTON
PCT/NZ99/00177
7-13-01

09/830145

4

Intellectual Property Office
of New Zealand
Te Pou Rāhui Hanga Hou

REC'D 16 DEC 1999
WIPO PCT

CERTIFICATE

This certificate is issued in support of an application for Patent registration in a country outside New Zealand pursuant to the Patents Act 1953 and the Regulations thereunder.

I hereby certify that annexed is a true copy of the Provisional Specification as filed on 23 October 1998 with an application for Letters Patent number 332473 made by CHRISTIAN JOHN COOK.

Dated 7 December 1999.

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

Neville Harris

Neville Harris
Commissioner of Patents

332473

NEW ZEALAND

PATENTS ACT, 1953

PROVISIONAL SPECIFICATION

IMPROVEMENTS IN OR RELATING TO ANIMAL SENSOR DEVICES

I, CHRISTIAN JOHN COOK, a New Zealand citizen of 70 Nevada Road, Hamilton, New Zealand, do hereby declare this invention to be described in the following statement:

INTELLECTUAL PROPERTY OFFICE OF N.Z.

23 OCT 1998

RECEIVED

IMPROVEMENTS IN OR RELATING TO ANIMAL SENSOR DEVICES

FIELD OF THE INVENTION

The present invention relates to methods of using animal temperature measurements to predict pH and stress levels, as well as meat quality in an animal. Also provided are animal identification tags incorporating temperature sensors. The devices are useful in monitoring the physiological state of an animal.

BACKGROUND ART

Livestock stress has long been recognised as having a major impact on the post-mortem quality of the animal tissue.[1,2,3,4,5]

It is well known that stress causes the depletion of an animals energy reserves through depletion of glycogen in muscle tissue, and causes an increase in pH. pH values in excess of 5.8 to 6.2 results in poor meat quality. Qualities affected include:

Colour: the higher the ultimate pH the darker the meat colour. Customer demand is for bright red, rather than dark, meats;
Keeping ability: which decreases with the increase in pH;
Texture: high pH's tend to produce rubbery, watery meats; and
Tenderness: both high and low pH meats may be tender.

However, because of the other disadvantages associated with high pH, low pH tender meat is preferable. High pH, poor quality meats are not suitable for the export market and are often down-graded resulting in multi-million dollar losses to the primary meat sector each year.

Major causes of stress include rounding up and lairage of animals on the farm, crowded transport conditions, driving animals over long distances without rest, and handling procedures at processing plants, such as prodding and washing. It has also been recognised that by feeding an animal prior to slaughter, muscle energy reserves can be restored and down-grading avoided.[4] In a ruminant animal such replenishment can take more than a day. In a monogastric, this is normally quicker. If a technology existed that could recognise at risk animals prior to processing then these animals could be treated.

It is an object of the present invention to provide a method for identifying stressed animals, or at least to provide the public with a useful choice.

The present applicant has found that in all animals subjected to stress, body temperature elevates leading to an increase in skin heat loss. Animals that have meat ultimate pH levels in an acceptable range (generally pH 5.5 to 6.2) show a weak correlation between body temperature at slaughter and the actual meat pH. This correlation is greater if increases in body temperature are integrated over 12 hours prior to slaughter. A convenient way to do this is to use a cumulative variance around an averaged body temperature for an individual animal. Higher cumulative variances in temperature predict higher pH meat, a measure that relates to the amount of glycogen residing in the meat. Based on the applicant's findings of the correlation between pH, temperature and stress, it is proposed that animal sensor devices may be produced to monitor body temperature, and its variance, as a measure of an animal's stress level and as a predictor of meat quality.

Animal temperature sensors are known in the art. For example, in US 3,781,837 and US 4,865,044, tympanic temperature sensors are employed. In US 4,854,328, a temperature sensor device is implanted at the base of an animals skull. An ear tag component is provided which incorporates a unit for receiving signals from the implanted sensor, and indicating means responsive to the generated signal. In the case of US 4,865,044, an ear tag is employed to contain the bulk of the temperature sensor circuitry, at a position remote from the tympanic animal temperature sensor.

The use of tympanic and surgically implanted sensor devices is usually contraindicated because of the high invasive load on the animal. Further, dislodgement problems are also encountered with tympanic sensors. Where implanted devices are used, incisions can easily become infected and the implantation procedure is more difficult to carry out.

Accordingly, it is a further object of this invention to provide a temperature sensing device which overcomes some of these disadvantages, or again at least provides the public with a useful choice.

In a first aspect, the present invention may be broadly said to consist in a method of measuring pH levels in an animal, the method comprising measuring an animal's body temperature and correlating the temperature reading with a pH standard.

Desirably, both temperature and its variance are measured over time and correlated with the pH standard.

In a further aspect, the present invention provides a method of measuring stress levels in an animal, the method comprising measuring an animal's body temperature, and calculating the variance around an averaged body temperature, a greater variance indicating a stressed animal.

Preferably, repeated body temperature measurements are taken at regular intervals over a predetermined period and integrated to give a cumulative temperature variance measurement.

For greater accuracy, body temperature measurements are also desirably integrated with ambient temperature measurements over the same period.

In another aspect, the present invention provides a method of measuring stress levels in an animal, the method comprising measuring the animal's pH level using a method of the invention, a pH level greater than 5.8 to 6.2 indicating a stressed animal.

A still further aspect of the present invention comprises a method of predicting pH levels in meat of a slaughtered animal, the method comprising measuring the animal's body temperature prior to slaughter, or preferably the variance in body temperature prior to slaughter, and correlating this reading with a pH standard.

Another aspect of the present invention provided is a method of predicting meat quality in a slaughtered animal, the method comprising measuring an animal's body temperature and preferably variance thereof, over a predetermined period prior to slaughter, a high variance indicating meat of poor quality.

In a further aspect, the present invention provides:

A temperature sensing device including:

a tag having an attachment portion for attachment of the tag to an animal, the tag incorporating an indicator means;
an ambient temperature sensing means provided on the tag;
an animal temperature sensor disposed on/in the tag for contact with the animal during use;
a comparison means to compare the environmental temperature with the animal temperature, the indicator means being responsive to the comparison means.

Preferably, the tag is an ear tag.

In a preferred embodiment, the sensor is provided on/in the attachment portion.

Desirably, the tag comprises a one piece moulded body.

Also contemplated by the present invention is the use of the temperature sensor devices in the methods of the invention as described above.

This invention may also be said broadly to consist in the parts, elements and features referred to or indicated in the specification of the application, individually or collectively, and any or all combinations of any two or more of said parts, elements or features, and where specific integers are mentioned herein which have known equivalents in the art to which this invention relates, such known equivalents are deemed to be incorporated herein as if individually set forth.

The invention consists in the foregoing and also envisages constructions of which the following give examples.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic view of an embodiment of a temperature sensing device of the present invention from the inward facing or "animal" side.

Figure 2 is a side view of a temperature sensing device of the present invention.

Figure 3 is a diagrammatic view of an embodiment of a temperature sensing device of the present invention from the outward facing or "environment" side.

Figure 4 is a graph correlating ultimate pH of meat with temperature variance. Below a pH of 6.0 no clear relationship exists. Variance in body temperature predicts only a pH above 6.0.

DETAILED DESCRIPTION

As summarised above, the present invention is based upon the applicant's unexpected finding of the correlation between stress, body temperature and variance in time of body temperature, pH and ultimately meat quality in livestock. This finding has important consequences for the agriculture industry generally and the primary meat industry in particular. By identifying stressed animals prior to slaughter, appropriate management techniques can be used to reduce the animals stress level. This will ensure a higher quality meat product after slaughter.

The applicant's findings also have broader application to methods of predicting or measuring pH levels based on the pH/temperature correlation.

Accordingly, in a first aspect, the present invention provides a method of measuring pH levels in an animal, the method comprising measuring an animal's body temperature and correlating the temperature reading with a pH standard.

Desirably, both temperature and its variance are measured over time and correlated with the pH standard.

In a further aspect, the present invention provides a method of measuring stress levels in an animal, the method comprising measuring the animal's pH level using a method of the invention, a pH level greater than 5.8 to 6.2 indicating a stressed animal.

In an extension of this method, temperature readings can be used as a predictor of pH levels in meat of a slaughtered animal. Accordingly, in a further aspect the present invention provides a method of predicting pH levels in meat of a slaughtered animal, the method comprising measuring the animal's body temperature, or preferably variance in body temperature, prior to slaughter and correlating the temperature reading with a pH standard.

From our discussions above, the reader will appreciate that the pH level predicted is an indicator of meat quality, with a pH level greater than 5.8 to 6.2 indicating meat of poor quality.

Therefore, in a related aspect, the present invention also provides a method of predicting meat quality in a slaughtered animal, the method comprising measuring an animal's body temperature and preferably variance thereof, over a predetermined period of time prior to

slaughter, a high variance indicating meat of poor quality.

Animal body temperature may be measured using a broad range of temperature sensors including tympanic, rectal, colonic, and skin sensors. Sensors ingested or inserted in bodily canals are not widely used due to the difficulty of inserting them, and because they are easily dislodged or expelled by an animal. Preferably, a skin temperature measurement is taken to avoid these invasive and less desirable alternative techniques. Conveniently, temperature may be measured using a temperature sensing device of the present invention discussed below. However, with temperature measurements from the skin as opposed to the body core, the ambient environmental temperature must been taken into account. The slope of prediction between variance in temperature and ultimate pH of meat shows consistency with temperature change. However, it shifts to the right, or to the left, depending upon the environmental temperature.

Integrated measures of animal and ambient air temperature, and usefully over a predetermined time period are also desirable. On the farm, any time interval desired may be selected. Continual on-line monitoring not limited to a specific time period is contemplated. Alternatively, monitoring for selected time periods of hours, days, weeks or even months is feasible.

In the slaughtering context, the correlation between body temperature at slaughter and pH levels of meat are stronger if the measures are integrated for an extended period, which may be up to 2-5 days, but is preferably between 3-36 hrs, more preferably 8-24 hrs and most preferably at least 12-14 hours prior to slaughter.

The applicant's have found that body temperature may reflect metabolic activities associated with the stress response. A greater stress response is likely to result in a greater metabolic activation, a corresponding greater generation of heat and elevation of body temperature. Except in circumstances of pathophysiological heat exhaustion, dehydration or febrile responses these elevations are usually short-lived in nature and small in magnitude.

Measurements of animal body-temperature that have been made at discrete points of time during the pre-slaughter period but such measurements are unlikely to give a representation of the stress experienced cumulatively over the preslaughter period. A single experienced stressor is unlikely to cause meat quality problems whereas cumulative stressor exposure over a period of time, without replenishment, will do so.

Correspondingly, single point temperature measures may well coincide with either a single stressor induced peak or a trough between numerous stressor induced peaks in body temperature, either way unlikely to provide an accurate assessment. It is for this reason that measurements over a predetermined time period prior to slaughter are preferred.

The applicant hypothesised that the best measure of energy used, and by correspondence glycogen depleted from muscles and predicted ultimate pH, would be the variance in body (or skin) temperature over time. The variance will represent both periods in which body temperature has fallen, and needs energy consumption to correct and periods in which body temperature has risen, reflecting increased metabolism and its energy consumption and necessitating heat loss.

Variance can be calculated in numerous ways. However, a simple cumulative measure using single measure sample period repeated over the required time is as follows:

- find the arithmetic average (x) of all the pooled samples (x1,....xn) where 1 = the first sample variable x and n the last in the sequence, which is also the total number of samples. x=(Sx1+x2+....... xn)/n

- measure and record the variance (v1,...vn) of each sample (x1...xn) from this average (x) (i.e. the difference between each sample and the average). Irrespective of whether each sample point is less or more than the average the difference will be indicated as a positive number. v1=x-x1,....vn=x-xn.

A further weighting needs to be given to each variance dependent upon whether it is above or below the mean. Values above the mean have energy associated both with generation (variance) and the energy loss through heat transfer needed to return to the average. As such their variance weighting will be greater than those below the average that utilises energy only in returning to the average baseline.

These numbers are then cumulatively added to give a variance score over a set-sampling time period. This time period will usually need to be 12 hours or greater to provide meaningful interpretation as to glycogen depletion and energy usage as discussed above. vc=Sv1+v2+....vn

The greater the cumulative score, the greater the energy usage that has occurred and correspondingly the greater the likelihood of both glycogen depletion and subsequent post-slaughter poor meat quality.

To calculate the prediction of meat quality a weighting must be given to the variance depending upon the environmental temperature. Increasing environmental temperatures are associated with a subtractive weighting, decreasing environmental temperatures with an additive weighting.

The weighting for this is approximately ± 0.2 pH unit per 3 ^{0}C above and below 20°C (standard weighting of zero).

Based on the applicant's determination of a correlation between temperature and pH, the body temperature can be manually or electronically correlated with pH using a pH standard. For example, standardised against a Mettler Toledo pH meter and standards (Mettler Toledo GmbH, Steinbach).

The pH level measured can be used as an indicator of an animal's stress level, a pH of greater than 5.8 to 6.2 indicating stress.

Where an animal is found to be stressed, remedial action to lower stress levels can be taken prior to slaughter. A period of feeding should alleviate stress by replenishing glycogen in muscle tissue. This action helps prevent or eliminate post-slaughter meat quality problems.

The methods of the invention may be used in relation to a broad range of animals including domesticated livestock such as sheep, cattle, deer, pigs, chickens, turkeys, ducks, emus, ostriches, rodents , chinchillas and additionally rabbits, possums, goats and the like, as well as the feral counterparts of all of these.

As noted above, the present invention also provides a temperature sensing device depicted generally by the numeral "10" in the accompanying figures. The sensing device (10) is useful in the methods of the invention for measuring temperature. A sensing device (10) of the invention includes a tag represented by the numeral "12". The tag (12) may comprise any of the tags known in the art which can be attached to the skin of an animal, including through the skin, folds thereof, or tissues. Examples of useful tags include ear tags, back tags and tail tags.

Ear tags are conveniently employed.

Two part ear tags are disclosed in US Patent No. 4,854,320 or three part tags of the type disclosed in US Patent No. 5,675,920 may be used. One part tags wherein an attachment

portion of the tag passes over the top of, and back through the ear and tag are also feasible. Currently preferred is a two part tag as illustrated in Figure 2. For example, the Tru-Test® perma-flex ear tag (Tru-Test Limited, 241 Ti Rakau Drive, East Tamaki, Auckland, New Zealand). The tags are generally useful for domestic livestock such as sheep, cattle, deer and goats but are not limited thereto.

The tag (12) incorporates at least one attachment portion (14). The attachment portion (14) comprises any suitable attachment means known in the art including any form of skin piercing. The attachment portion (14) may be selected according to the position of attachment on the animal. Suitable attachment portions may include shafts, bands, hooks insertable into or through selected animal tissues, or attachment portions adherable thereto. For example, tags could be superglued to the skin of an animal at a desired location. Preferably, the attachment portion (14) includes a shaft (17) insertable through the ear of an animal. Where necessary backing member(s) (15) may be used to securely fasten the tag to the ear of the animal. The backing member (15) may include a further tag body in some cases. Alternatively, in one embodiment discussed above, the attachment portion (14) may be secured back to the tag (12).

The tag (12) incorporates at least one animal temperature sensor (20) disposed on or in the tag. The sensor (20) is disposed at any location on or in the tag (12) which ensures contact of the sensor (20) with the animal during use. In one embodiment the sensor (20) is in the vicinity of the attachment portion (14). In a preferred embodiment shown in Figure 2, the sensor (20) is provided on or in the shaft (17) of the attachment portion (14). The location of the sensor (20) in the shaft (17) ensures close contact of the sensor with the animal ear.

The temperature sensor (20) itself may comprise any suitable sensing means known in the art including electronic sensors or thermistors. Temperature sensors suitable for use in the invention are disclosed in US 4,854,328 and US 4,865,044 at least.

As discussed above, where skin temperature readings are used as opposed to body core readings, then the ambient environmental temperature should also be measured. For example, on a hot day an animal's body temperature will rise. If not correlated with air temperature this would falsely indicate a stressed or sick animal. Logically therefore, a more accurate assessment of an animal's body temperature can be made if the ambient air temperature is taken into account.

Accordingly, while a tag (12) without an ambient temperature sensor is contemplated, the tag (12) preferably further includes at least one ambient temperature sensing means (18)

provided on the tag (12) at any position suitable for measuring ambient air temperature. Most usually, the ambient temperature sensor (18) will be disposed on or in the side of the tag (12) away from the animal, as shown in Figure 1. Temperature sensors of the type used for animal temperature measurement may also be employed for ambient temperature measurement. Such other air temperature sensors as are known in the art may also be used.

Correlation of both body and air temperature data can be performed manually by an observer. However, it is preferred that the sensing device (10) further include comparison means for correlating temperature data from both the air and body temperature sensors (18 and 20). Usually, the comparison means will be a microprocessor (22).

The data output of the body and/or temperature sensor means (18 and 20) may also or alternatively, be sent to remote evaluation means. This will generally require the coupling of the sensor means (18 and 20) to a transmitter. Data is transmitted to remote comparison means such as a computer. In the case of tagged animals this will permit remote monitoring and checking to be performed, continuously if desired.

In the presently preferred embodiment, the temperature information gathered by both sensors (18 and 20) is relayed to microprocessor (22). Reference is made to US 4,854,328, US 4,865,044 and US 3,781,837 which disclose circuitry which could be adapted for this use. A preferred processor for use is the PIC processor already in use by Tru-Test® Limited in their identification ear tag.

The microprocessor (22) is in turn in responsive communication with indicator means (16). The indicator means (16) may be selected from a broad range of currently known indicators including electronic, visual and acoustic signal generators but are not limited thereto.

In the case of an electronic indicator this may be a device programmed to give out a perceivable signal once a certain predetermined temperature is reached.

In one embodiment, the indicator means (16) may comprise a temperature responsive substance which generates a visual, electromagnetic, electrochemical, or other measurable signal when a predetermined temperature is exceeded. Visual changes such as a change in colour are conveniently employed. Colour change indicators will generally comprise a substance which undergoes a change in state at a precise and predetermined temperature.

In a further embodiment, the indicator means (16) may comprise a plurality of regions,

generally less than 10 and preferably less than 5, which undergo a change of state at precise, graduated predetermined temperatures. When colour changes are employed this may usefully result in the graduated change in colour of the indicator from a small portion to substantially the entire indicator as the temperature rises. Alternatives include a "traffic light" indicator which, for example, changes from green, to amber, to red as the temperature rises. Other possibilities include opaque materials becoming transparent or translucent to reveal underlying colours as the temperature changes.

The indicators may undergo irreversible changes, especially when continuous monitoring is not contemplated.

Further visual indicator means (16) include, for example, LEDs or flashing lights. Alternatively, audible alarms may be triggered. Combinations of all such indicator means are also feasible. Also contemplated are outputs readable at remote locations. A wide range of indicator means (16) which may be employed in the invention are disclosed in the following US patents: US 3,781,837, US 4,865,044, US 4,854,328 and US 5,675,920 amongst others.

Depending on the types of sensors, indicator and comparison means employed, the sensor device may require a power source. While solar powered devices are contemplated, at least one battery will usually be incorporated into the sensing device (10). In the preferred embodiment depicted in Figure 1, a battery "24" is employed. A wide variety of batteries (24) are currently available and suitable for use in the ear tag (12).

Where batteries (24) are employed as a power source it is important to identify when a battery (24) has malfunctioned or expired. An indicator showing when the power source has failed would therefore be useful. An appropriate indicator is identified by the numeral "26" in Figure 1. As with the sensing means, useful indicators include electronic, audio and visual signals as discussed above. For example, when the battery has failed an audible signal could be emitted. Preferably however, the signal is a visual colour change signal, or extinction of an "OK" LED signal. The colour change may be signalled as an alternative to the temperature colour change signal, or in addition to it provided that the colour changes are distinctive.

The tag(12) may further incorporate communication means. The communication may comprise the export of data and/or for the import of energy. Accordingly, uni- and bi-directional communication means are contemplated. Suitable communication means are identified in the US patents referenced above. They include at least one transmitter and/or

antenna but are not limited thereto. In a preferred embodiment of the present invention an antenna (28) is included in the tag (12). The antenna (28) preferably allows bi-directional data communication with the tag (12).

In one use, the antenna (28) provides a means of recharging the battery (24) by use of electromagnetic radiation or an extra radio frequency field. In a further use, the antenna (28) permits communication of data for logging purposes. Communication may be to remote data logging means to facilitate off site monitoring of animals.

It is also customary for tags (12) to include animal identification means. In a simple form this may comprise a unique visual identification means such as a symbol, colour or pattern. Preferably, the visual ID comprises an alphamerical number (30) as shown in Figure 3. Alternate identification means include electronic identifications, or electronically readable signals which uniquely identify a given animal. Any such electronic signals which are known in the art may be used. One embodiment preferred is the inclusion of a barcode (32) on the tag (12) as shown in Figure 3. This facilitates scanning of the tag (12) and correlation of data with pre-existing information for the uniquely identified animal. Specific identification systems can also assist in discouraging theft of stock.

Where electronic identification means are employed, the microprocessor (22) and antenna (28) of the tag (12) may further communicate therewith.

The electronic componentry of the ear tag (12) comprising any of all of the antenna (28), battery (24), battery indicator (26) and microprocessor (22) may be provided on or in the tag (12) conveniently on a circuit board (34). Preferably, the componentry is provided within the tag (12) to prevent damage. This may be achieved by covering the componentry once fixed on the tag (12). The cover may be permanently fixed in place or can be releasable. A releasable cover would allow for battery replacement. If the cover is fixed, this may be achieved by gluing, plastic welding or other known fastening means.

Conveniently, the tag (12) is a one piece moulded body.

In a preferred form the tag (12) comprises an integrally moulded body with the componentry sealed therein.

In use, the temperature sensors (18 and 20) of the ear tag (12) will collect temperature data which is communicated to the microprocessor (22) to perform the necessary temperature

correlation algorithms discussed above.

If the outcome of the calculation is a temperature threshold value that indicates a pH of poor quality (greater than 6.2) then a power surge is directed to the indicator to cause a electronic, visual or audible change. The livestock owner or manager can then take steps to reduce the stress level in the animal through appropriate feeding regimes.

High temperature readings may also indicate infected or otherwise unhealthy animals. The tags can therefore serve the dual purpose of signalling the state of health of the animal apart from stress responses.

The useable lifetime of the tag is approximately one month. The lifespan of the tag can be extended through the incorporation of a battery (24) able to be recharged by electromagnetic radiation or radio frequency in the field. Accordingly, both disposable single measure tags (12) and reusable tags (12) are contemplated herein. Disposable tags (12) may be particularly appropriate for short term use in the pre-slaughter period.

Non-limiting examples illustrating the invention will now be provided.

EXAMPLE 1

Data were obtained in the following manner:
Three groups of twenty prime bulls (18 months of age) were exposed to periods of stressful handling during a 24h lead up period to slaughter.

During this time skin temperature from the ear of each individual animals was measured every 10 minutes. From this an average was calculated and the cumulative variance measured by adding each individual measure difference from the average.

Cumulative variances were then plotted against individual ultimate pH values obtained post-slaughter from meat. Variance values against a set ultimate pH value are presented as an average and standard deviation.

Each group of animals was exposed to a different controlled ambient temperature 16, 20 or 24 Celsius for the trial period.

In each case the correlation coefficient r^2 was greater than 0.90 for variance in temperature predicting ultimate pH of meat.

Figure 4 presents data for the relationship between variance in temperature and ultimate pH of the meat. Note that below a pH of 6.0 no clear relationship exists. As depicted, variance in body temperature predicts only a pH above 6.0.

For ultimate pH prediction an equation can be calculated to provide an algorithm combining the cumulated variance and the environment temperature.

It will be appreciated that the above description is provided by way of example only and that variations in both the materials and techniques used which are known to those persons skilled in the art are contemplated.

REFERENCES

1 Cook, C.J. and Devine C.E. (1990) From farm paddock to slaughter floor: a conundrum of biochemical and physiological effects that influence meat quality. AGMARDT Beef Industry Research Development Conference. NZMPB.

2 Purchas, R.W. (1990) An assessment of the role of pH differences in determining the relative tenderness of meat from bulls and steers. Meat Sciences 27, 129-140.

3 Watanabe, A., Daly, C.C. and Devine C.E. (1995) The effects of ultimate pH of meat on the tenderness changes during ageing. Meat Science 42, 67-78.

4 Jacobson, L.H. and Cook, C.J. (1997) The effect of pre-transport cattle management on stress, metabolism and carcass weight of bulls. In: Proceedings of the 43rd International Congress on Meat Science and Technology. Auckland, NZ, pp302-303.

5 Jacobson, L.H., Cook, C.J., Hodgetts, B.V. and Dean, J.M. The effect of pre-transport on on-farm holding and supplementary feeding, on welfare and meat characteristics of bulls subsequently transported for slaughter. September 1997 . (Funding Milestone, MRDC).

6 All US references cited in the text of this specification are incorporated herein by reference.

CHRISTIAN JOHN COOK
By the authorised agents
A. J Park & Son
Per AJPark

332473

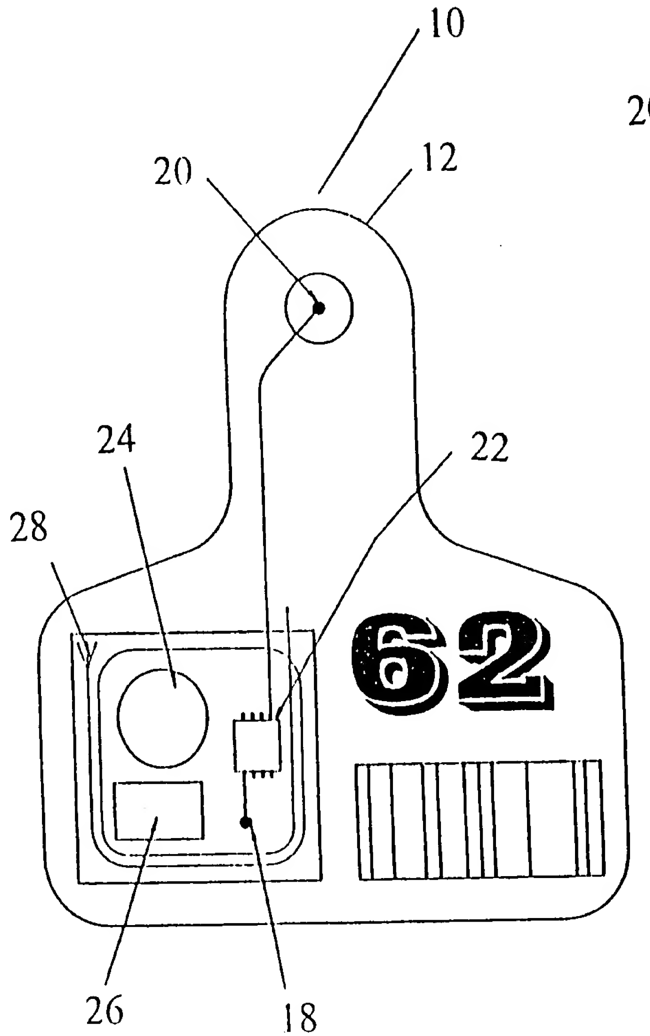


Figure 1

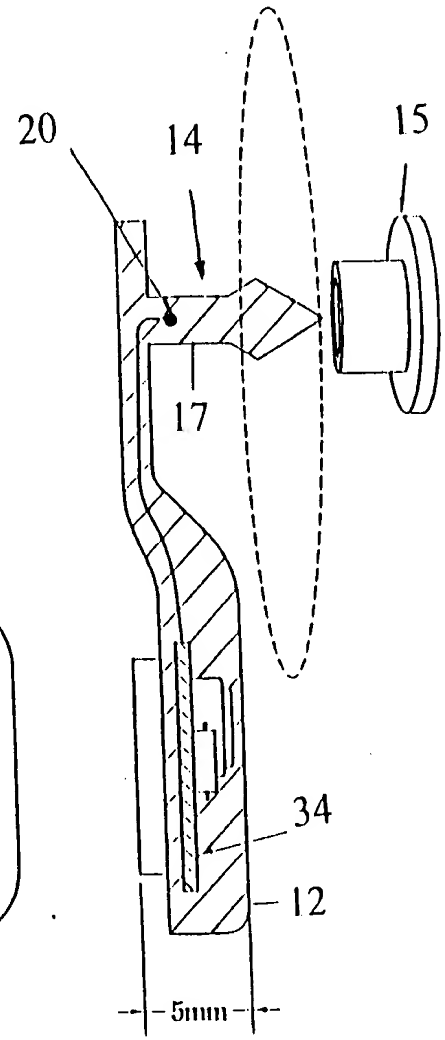


Figure 2

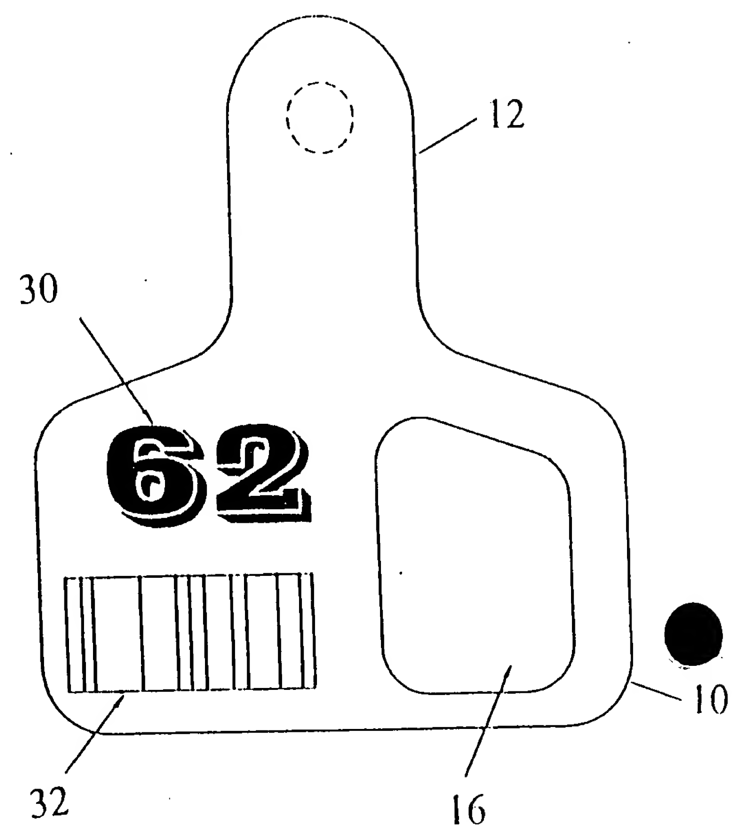
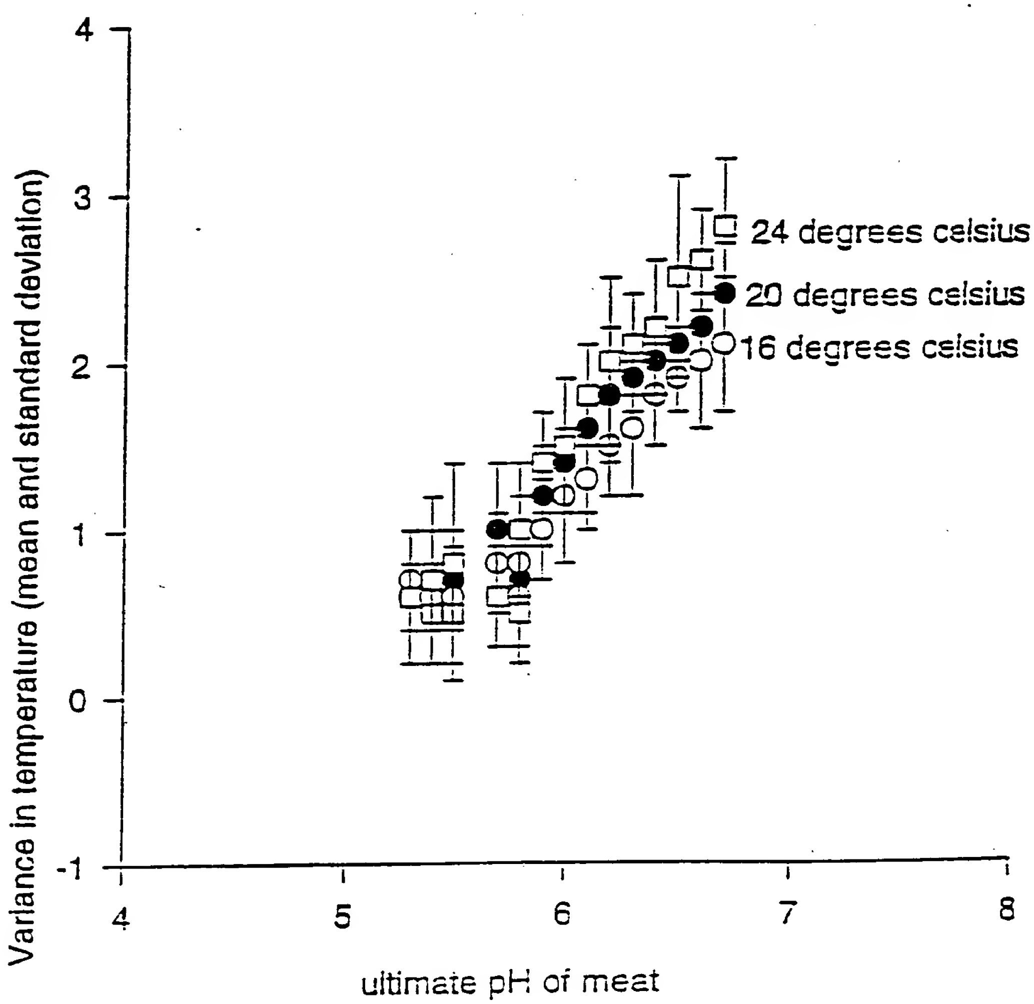


Figure 3



4
3
2
1
0
-1
Variance in temperature (mean and standard deviation)
24 degrees celsius
20 degrees celsius
16 degrees celsius
4
5
6
7
8
ultimate pH of meat

Figure 4